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Dusting vs. Spraying in the Apple Orchard



By

N. J. GIDDINGS

ANTHONY BERG and E. C. SHERWOOD

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-------------------------	-----------

*In cooperation with the U. S. Department of Agriculture, Washington, D. C.

†In charge of the Lakin Sub-Station, Lakin, W. Va.

**In cooperation with the State Department of Agriculture, Charleston, W. Va.

‡In charge of the Reymann Memorial Farms, Wardensville, W. Va.

*Dusting vs. Spraying in the Apple Orchard**

The experimental work discussed in this bulletin was begun in 1913 in cooperation with the Department of Entomology.† Tests with dust for control of peach diseases gave evidence of so much greater practical value than did the work with apples that special attention was given to this phase of the problem and the results for the years 1914 to 1917, inclusive, were published as Bulletin 167 of this Station. Since that time the experiments with dust have been continued in commercial apple orchards.

It was hoped that some combination of materials, equipment, and methods would be developed by means of which effective control of apple diseases with dust would be secured, and which would be of practical use to the fruit grower.

The results of the work have been made available to the fruit growers of the state from year to year by means of papers and discussions at the meetings of the State Horticultural Society and through the Extension Specialist in Plant Pathology. The present publication summarizes the work with apples to date.

In 1913 the apples were all killed by late freezes in two orchards where dusting and spraying experiments were undertaken. The orchards used during 1914 and 1915 were remarkably free from fungous diseases, except rust and black rot, and there was practically no evidence of control of these. In 1916 there were no experiments conducted with apples, but the work was again taken up in 1917, under conditions which gave promise of more definite disease control data.

In each of the experiments described in this bulletin, every reasonable effort was made to see that the trees were thoroughly coated with dust. The work was usually done in the early morning when the air was quiet and the foliage was still wet with dew, but some dust applications were made in the evening. Applications of dust were not made in the middle of the day because there was usually a breeze which would seriously interfere and it seemed desirable to have the material moistened by dew as soon as possible after applying. Early

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†As the dust materials appeared to give satisfactory insect control, the Department of Entomology discontinued active cooperation on this project, after the 1917 season. Professor L. M. Peairs and Mr. W. E. Rumsey assisted in the work and secured data on insect control previous to the 1918 season.

morning applications, while the leaves were still moist, seemed most satisfactory. In all of the later work, the trees were dusted from both sides.

EXPERIMENTS IN 1917

The experiments in 1917 were conducted on 11-year old Rome trees in the J. H. Stewart orchard at Raymond City. The equipment consisted of a large Niagara power duster and a Bean power sprayer. The materials used were 90-10 sulphur-arsenate dust, a copper-lime dust containing one part commercial Bordeaux powder (11% copper)

TABLE 1.—The effectiveness of certain treatments in preventing diseases and insect injuries on apple fruits. Fruit harvested September 21 to October 2, 1917.

Treatment	Fruit Picked or Dropped	Fruits Affected by Sooty Blotch		Fruits Affected by Scab		Total Fruit Examined*			Culls†	
		Number	Percent	Number	Percent	Number	Bushels	Fruits Per Bu.	Number	Percent
Dust Sulphur (90-10)	Picked	2918	99.7	2881	98.7	2924	12.0	244	305	10
Dust Sulphur (90-10)	Dropped	575	100.0	573	99.7	575				
Lime Sulphur Spray	Picked	2203	99.6	2086	94.5	2211	10.5	211	136	6.2
Lime Sulphur Spray	Dropped	1010	99.6	976	96.3	1014				
Untreated	Picked	1429	100.0	1416	99.1	1429	5.0	286	105	7.0
Untreated	Dropped	1167	100.0	1163	99.7	1167				
Bordeaux Spray . . .	Picked	1696	99.7	963	56.6	1701	11.0	155	6	0.4
Bordeaux Spray . . .	Dropped	292	99.7	225	76.7	293				
Bordeaux Dust	Picked	1807	100.0	1791	99.1	1807	8.0	226	61	3.4
Bordeaux Dust	Dropped	1181	100.0	1157	97.9	1181				
Untreated	Picked	978	100.0	976	99.8	978	3.6	270	112	12.5
Untreated	Dropped	322	100.0	319	99.1	322				

*The column headed, "Fruits per bushel", gives a very good idea of the relative size of the apples.

†Fruit was not sorted into grades but any which was considered as absolutely unmarketable was placed in culls.

to two parts lime, 3-5-50 Bordeaux spray, and 1-40 lime-sulphur spray. The pink or cluster bud application was omitted.

Applications were made as follows:

May 9, all materials (calyx spray)

July 16, all materials*

The amount of dust used per tree, per application, was about two-thirds pound of the sulphur-arsenate and one-third pound of the copper-lime.

The fruit showed practically a hundred percent infection of both scab and sooty blotch. There was no evidence of sooty blotch control by any of the materials used, and the only evidence of scab control was by the Bordeaux spray. The amount of insect injury was not sufficient to be of much importance, but there was no indication of control by any of the materials used.

In the three columns under "total fruit" of Table 1, there is some very interesting evidence as to the effect of treatments upon sizes of fruit. It required only 155 average apples from the Bordeaux sprayed plot to make a bushel while from the adjoining check plot it required 286 apples to make a bushel. It is believed that this difference in size was largely due to control of black rot leaf spot, and scab infections upon the leaves. No detailed leaf data were secured, but it was observed that the check plots lost their foliage first and the Bordeaux sprayed plot retained its foliage longest.

EXPERIMENTS IN 1918

The trees in the 1918 experiments were of the Rome variety and twelve years old in the J. H. Stewart orchard at Raymond City. The equipment consisted of a large Niagara power duster and a Bean power sprayer. The materials used were 90-10 sulphur-arsenate dust, 3-5-50 Bordeaux mixture, and dry lime-sulphur used at the rate of 3 pounds to 50 gallons of water.

Applications were made as follows:

April 13, Sulphur-arsenate dust (pink spray)

April 16, Bordeaux Spray (pink spray)†

April 18, Dry lime sulphur spray (pink spray)

April 27, All materials (calyx spray)

May 24, All materials

The sulphur-arsenate dust was used at the rate of about one pound per tree and the spray at from two and one-half to three gallons per tree. The Bordeaux spray was applied under difficulties, which resulted in a very poor application.

*A more complete schedule of applications was intended, but the entry of this country into the World War disorganized the Plant Pathology Department quite seriously and prevented carrying out the spray program.

†The delay in the first applications of spray was due to the breaking of the pump.

TABLE 2.—The effectiveness of certain treatments in preventing leaf spot and scab on apple. Leaves collected July 9, 1918.

TREATMENT	BLACK ROT LEAF SPOT						SCAB					
	Distribution of Percentages of Leaves Showing Various Numbers of Spots per Leaf			Distribution of Percentages of Leaves Showing Various Degrees of Scab			Leaves Showing Scab			Leaves Showing Heavy Scab		
	No. Spots	1-4 Spots	5-9 Spots	10-24 Spots	25-49 Spots	50-74 Spots	75 or more Spots	None	Light	Medium	Heavy	Missing
Untreated . . .				29.6	31.1	39.3	100.0	60.1	41.3	12.5	29.7	58.7
Lime Sulphur Spray . . .	40.5	13.3	11.6	19.5	15.1			59.5	17.3	70.8	7.5	13.7
Sulphur Dust	49.7	24.6	10.6	11.0	4.1			50.3	9.7	62.1	8.7	15.6
Bordeaux Spray . . .	40.0	41.5	10.8	6.8	0.8			59.9	5.8	78.0	7.4	11.0
												3.6
												22.0
												*
												472

[†]The missing leaves were doubtless badly diseased, but percentages were figured on the basis of leaves examined.

*Less than one percent of leaves gone.

Typical twigs for leaf data were collected on July 8. In choosing materials for leaf data care was exercised to select terminal growths which fairly represented the general conditions and these were taken from different portions of the tree.

Table 2 shows the very heavy infection from leaf spot, and the average number of spots per infected leaf in the check plot is worthy of special note. The scab infection was also quite heavy. The greater number of leaves free from leaf spot in the dusted plot than in the Bordeaux plot was offset by more spots per leaf. The dust showed very good control of leaf spot and fair control of leaf scab, but a glance at Table 3 shows that scab control on fruit was very slight in the case of dust. The fact that both sprays were delayed would normally be a handicap in favor of the dust, but the Bordeaux was thoroughly effective, although a further delay, such as was required for the lime-sulphur, might have been more serious.

TABLE 3.—The effectiveness of certain treatments in preventing scab and sooty blotch on apple fruit. Fruit harvested September 30 to October 2, 1918.

TREATMENT	Distribution of Percentages of Fruits Showing Various Degrees of Scab				Percentage of Scabby Fruits	Percentage of Fruits Affected by Sooty Blotch	Number of Fruits Examined
	None	Light	Medium	Heavy			
Untreated			6.2	93.8	100.0	100.0	1153
Dry Lime-Sulphur Spray . .	2.2	12.7	12.8	72.3	97.8	95.8	1441
Sulphur Dust	8.5	34.2	35.2	22.1	91.5	88.1	2016
Bordeaux Spray	76.4	17.4	4.4	1.8	23.6	19.3	1724

EXPERIMENTS IN 1919

The experiments in 1919 were conducted in the J. H. Stewart orchard at Raymond City on thirteen year old Rome trees. The equipment consisted of a large power Niaraga duster and a Bean power sprayer. Several new materials were tested and, in the case of Bordeaux spray, some data were secured as to the most important time of application. The materials used were 90-10 sulphur-arsenate dust; 3-5-50 Bordeaux mixture; dry lime-sulphur spray, $3\frac{1}{2}$ pounds to 50 gallons; and three special dusts as follows:

TABLE 4.—The effectiveness of certain treatments in preventing leaf spot and scab on apple. Leaves collected July 18, 1919.

TREATMENT	BLACK ROT LEAF SPOT						SCAB					
	Distribution of Percentages of Leaves Showing Various Numbers of Spots per Leaf			Percentage of Infected Leaves			Distribution of Percentages of Leaves Showing Various Degrees of Scab			Percentage of Leaves Showing Various Degrees of Scab		
	No. Spots	1-4 Spots	5-9 Spots	10-24 Spots	25-50 Spots	51-100 Spots	None	Light	Medium	Heavy	None	Light
Sulphur Dust	39.2	45.5.	9.7	1.6	60.8	2.8	30.2	66.6	2.9	0.3	69.8	311
Bordeaux Spray Applications 2 and 3	47.5	45.4	5.6	1.5	52.5	2.5	40.8	58.2	1.0	0.0	59.2	196
Bordeaux Spray Applications 1, 2, and 3	46.7	49.2	4.1	0.0	53.3	2.2	36.4	62.6	1.0	0.0	63.6	195
Bordeaux Spray Application 3	21.2	53.4	21.2	4.2	78.8	3.9	16.6	82.4	1.0	0.0	83.4	193
Untreated	21.9	32.3	21.9	21.9	78.1	6.4	24.6	62.9	6.6	5.5	75.4	183
Lime-Sulphur Spray	65.0	33.6	1.4	0.0	35.0	2.0	38.5	61.5	0.0	0.0	61.5	288
Dust No. 2	38.5	50.3	9.9	1.3	61.5	2.8	31.2	61.8	7.0	0.0	68.8	223
Dust No. 3	41.5	46.1	8.7	3.7	58.5	3.6	31.2	67.2	1.2	0.0	68.8	241
Dust No. 5	25.4	41.1	25.4	8.1	74.6	5.0	43.2	53.8	3.0	0.0	56.8	197

Dust No. 2

3-5-50 Bordeaux dried and ground	50%
Hydrated lime	47.5%
Acacia	2.5%

Dust No. 3

Dehydrated copper sulphate	20%
Hydrated lime	78%
Copper carbonate	2%

Dust No. 5

Dry lime sulphur	50%
Rye flour	50%

The acacia and the rye flour were used with a view to increasing the adhesiveness of the dusts. The sulphur-arsenate dust and the lime-sulphur rye-flour dust were applied at the rate of about one pound per tree, while the copper dusts were used at the rate of about one-half pound per tree.

Applications were made as follows:

April 18, Bordeaux spray (pink spray)
 April 19, Lime sulphur spray and all dusts (pink spray)
 May 3, Lime sulphur spray (calyx spray)
 May 5, Bordeaux spray and all dusts (calyx spray)
 May 28, Bordeaux spray and lime sulphur spray
 May 29, All dusts

On the Bordeaux plots shown in Tables 4 and 5, application 1 was made April 18; application 2, May 5; and application 3, May 28.

It may be noted from Table 4 that the amount of leaf spot was much less than in 1918 while the amount of leaf scab was greater. Very few of the leaves showed either medium or heavy scab infection, but there were spots on a very high percentage of the leaves. The first two or three leaves on a terminal (the oldest leaves) were most often free of scab infection. The leaf spot was most severe on leaves 2 to 6 of terminal growth, (leaf 2 being the second large leaf to emerge from the bud).

Practically no leaves had fallen at the time of taking data (July 18). Leaf samples from the Bordeaux plot receiving applications 1 and 2 were accidentally omitted.

The lime-sulphur spray gave most effective control of leaf spot while none of the materials reduced the amount of leaf scab infection very markedly.

The data given in Table 5 were taken on all the fruit from one tree each in the case of Dust No. 2, Dust No. 3, and Dust No. 5, while all the fruit from three trees was used in the case of the check plot. The fruit in each of the other plots was all harvested separately and

TABLE 5.—The effectiveness of certain treatments in preventing scab and sooty blotch on apple fruit. Fruit harvested September 24 and 25, 1919.

TREATMENT	Distribution of Percentages of Fruits Showing Various Degrees of Scab				Percentage of Scabby Fruit	Percentage of Fruits Affected by Sooty Blotch	Number of Fruits Examined
	None	Light	Medium	Heavy			
Sulphur Dust	17.1	37.7	24.5	20.7	82.9	100.0	657
Bordeaux Spray, Applications 1 and 2	61.5	15.1	16.5	6.9	38.5	100.0	509
Bordeaux Spray, Applications 2 and 3	59.5	20.8	17.0	2.7	40.5	97.3	447
Bordeaux Spray, Applications 1, 2, and 3	70.2	15.4	11.3	3.1	29.8	84.5	521
Bordeaux Spray, Application 3	1.7	10.7	19.2	68.4	98.3	100.0	479
Untreated	1.6	9.1	19.5	69.8	98.4	100.0	374
Lime-Sulphur Spray	45.9	23.6	18.9	11.6	54.1	100.0	567
Dust No. 2	4.1	25.1	30.8	40.0	95.9	100.0	195
Dust No. 3	12.9	33.3	24.6	29.2	87.1	100.0	171
Dust No. 5	1.2	15.8	31.6	51.4	98.8	100.0	171

piled up. Then a typical three bushel sample was taken for the purpose of securing individual fruit data. Some idea may be obtained as to the relative size of the fruits by noting the number required for three bushels in the sulphur dust, lime-sulphur spray, and the various Bordeaux spray plots (last column, Table 5).

The fruit infection from scab, and sooty blotch was fully as severe as in 1918. Sooty blotch was not satisfactorily controlled by any of the materials used. The Bordeaux spray was very effective against scab, and it would seem that the second (calyx) application was the most important under the conditions existing in that orchard during the 1919 season. The earlier applications are undoubtedly of great importance many seasons. The lime-sulphur spray was next in effectiveness and sulphur-arsenate dust next, although none of the dusts was at all satisfactory.

EXPERIMENTS IN 1920

During the season of 1920 the experiments were again conducted in the Stewart orchard at Raymond City, and also in the Bowers orchard at Bunker Hill.

New materials tested in connection with this work were:

Dust No. 6

Bug Death, (a commercial proprietary compound containing a high percentage of zinc oxide).

Dust No. 7

Superfine sulphur	75%
Dry lime sulphur	15%
Arsenate of lead	10%

Dust No. 8

Dehydrated copper sulphate	15%
Hydrated lime	60%
Venetian red (Ferric oxide)	15%
Arsenate of lead	10%

Dust No. 9

Commercial Bordeaux dust (11% copper)	45%
Hydrated lime	45%
Arsenate of lead	10%

The standard 90-10 sulphur-arsenate dust, 3-5-50 Bordeaux spray, and 1-40 lime-sulphur spray were also used.

At Raymond City

In the experiments at Raymond City the trees were of the Rome variety and fourteen years old. The equipment consisted of a large power Niagara duster and a Bean power sprayer.

Applications were made as follows:

April 23, Dry lime sulphur spray
April 24, Bordeaux spray
April 30, Dusts
May 6, Bordeaux and lime sulphur sprays
May 12, Dusts
May 15, Dusts
May 26, Bordeaux and lime sulphur sprays
June 1, Dusts
June 25, Bordeaux and lime sulphur sprays
June 30, Dusts

There was some delay in making the first application of dust, and the trees were nearly in bloom at that time.

Leaf spot and scab were considerably more severe in 1920 than in 1919, but Table 6 shows that very effective control was secured with dust as well as spray. The results would indicate that practically no scab infection had taken place on April 30. The dust No. 7 (sulphur-lime-sulphur) appeared to be more effective than any other material used, while Bordeaux spray was next in value.

The fruit infection on unsprayed trees as shown in Table 7 was nearly a hundred percent for both scab and sooty blotch. In the

TABLE 6.—The effectiveness of certain treatments in preventing leaf spot and scab on apple. Leaves collected July 12, 1920.

TREATMENT	BLACK ROT LEAF SPOT						SCAB					
	Distribution of Percentages of Leaves Showing Various Number of Spots per Leaf			Distribution of Percentages of Leaves Showing Various Degree of Scab			Leaves With Scab			Leaves		
	No Spots	1-4 Spots	5-9 Spots	10-24 Spots	25-49 Spots	Leaf Spots per Leaf	Average Number of Leaves Infected	Percentage of Leaves Infected				
Untreated	20.0	18.4	12.0	19.2	30.4	80.0	20.8	46.4	19.2	8.0	26.4	53.6 .
Sulphur Dust	53.6	34.5	11.9	0.0	0.0	46.4	3.5	89.9	10.1	0.0	0.0	10.1
Bordeaux Spray	67.1	26.5	6.4	0.0	0.0	32.9	2.8	92.3	7.7	0.0	0.0	7.7
Dust No. 7	73.6	25.6	0.8	0.0	0.0	26.4	1.7	96.1	3.6	0.3	0.0	3.9
Dust No. 8	35.2	41.5	13.6	9.7	0.0	64.8	5.0	83.7	14.3	1.3	0.7	16.3
Dust No. 9	39.6	33.5	17.9	9.0	0.0	60.4	5.0	85.1	13.4	1.5	0.0	14.9

TABLE 7.—The effectiveness of certain treatments in preventing scab and sooty blotch on apple fruits. Fruit harvested September 18 to 21, 1920.

TREATMENT	Distribution of Percentages of Fruits Showing Various Degrees of Scab				Percentage of Scabby Fruit	Percentage of Fruits Affected by Sooty Blotch	Number of Fruits Examined
	None	Light	Medium	Heavy			
Sulphur Dust	28.8	23.6	21.6	26.0	71.2	79.7	901
Untreated	4.8	18.3	37.4	39.5	95.2	99.5	1292
Bordeaux Spray	78.5	8.1	7.8	5.6	21.5	5.0	1045
Dust No. 7	48.2	19.7	14.4	17.7	51.8	64.2	1141
Dust No. 8	40.2	38.5	8.7	12.8	59.8	82.6	1298
Dust No. 9	9.4	39.9	24.9	26.1	90.6	61.9	593

control of these diseases on apples the Bordeaux spray stands out by itself. The dust No. 7 was slightly more effective than any of the other dusts, but could not be considered satisfactory.

At Bunker Hill

In the experiments at Bunker Hill the work was conducted in the Bowers orchard on trees of the Ben Davis variety, eighteen years old. The equipment consisted of a small Kansas City power duster and a Domestic power sprayer.

Applications were made as follows:

- April 26, All materials (pink spray)
- May 10, All materials (calyx spray)
- May 17, Sulphur dust on special plot
- May 22, All materials
- May 27, Sulphur dust on special plot

The average amount of dust used per tree was:

- Sulphur arsenate $1\frac{1}{2}$ pounds
- Dust No. 6 2 pounds
- Dust No. 9 1 pound

The trees were dusted from both sides and nine trees in the sulphur-arsenate block received two extra applications, as may be seen in the schedule of applications. There was very little black rot leaf spot and no data on it were taken.

It may be seen from Table 8 that the sulphur dust gave fair control of leaf scab, but Bordeaux was most effective, and lime-sulphur

TABLE 8.—The effectiveness of certain treatments in preventing scab on apple.
Leaves collected July 9, 1920.

TREATMENT	Distribution of Percentages of Leaves Showing Various Degrees of Scab				Percentage of Leaves With Scab	Percentage of Leaves Missing	Number of Leaves Examined
	None	Light	Medium	Heavy			
Sulphur Dust (5 applications)	64.3	23.8	10.9	0.5	35.7	5.2	193
Lime Sulphur Spray	75.4	24.6	0.0	0.0	24.6	5.3	228
Untreated	14.4	61.0	16.1	8.5	85.6	5.9	236
Bordeaux Spray	98.2	1.8	0.0	0.0	1.8	*	326
Dust No. 9	37.6	51.2	9.9	1.3	62.4	3.6	223
Dust No. 6	57.6	35.7	4.9	1.8	42.4	*	283

*Less than one percent of leaves gone.

spray next. There was a small percentage of leaf injury attributable to the Bordeaux.



The scab infection was rather uniformly distributed on all leaves, although leaves 8 to 10 and 14 to 16 on terminal growths showed the greatest amount of injury.

The greater efficiency of the sprays is brought out more markedly in the fruit data given in Table 9. The Bordeaux spray was very satisfactory and lime-sulphur quite good, while the amount of scab was reduced very little by any of the dusts.

TABLE 9.—The effectiveness of certain treatments in preventing scab and sooty blotch on apple fruits. Fruit harvested October 19 to 21, 1920.

TREATMENT	Distribution of Percentages of Fruits Showing Various Degrees of Scab				Percentage of Scabby Fruits	Percentage of Fruits Affected by Sooty Blotch	Number of Fruits Examined
	None	Light	Medium	Heavy			
Sulphur Dust (3 Applications)	24.1	33.8	23.6	18.5	75.9	5.9	373
Sulphur Dust (5 Applications)	21.2	34.6	26.0	18.3	78.8	33.3	803
Lime-Sulphur Spray ..	54.0	28.3	12.6	5.1	46.0	7.6	1392
Untreated	8.9	20.0	31.7	39.4	91.1	10.2	1326
Bordeaux Spray	68.7	17.8	9.6	3.9	31.3	0.0	1250
Dust No. 9	19.6	35.3	29.5	15.7	80.4	12.8	1364
Dust No. 6	15.7	35.4	30.4	18.5	84.3	2.9	421

EXPERIMENTS IN 1921

The experimental work in 1921 was carried on at Raymond City and at Inwood. Special dusts used this season were:

Dust No. 7

Superfine sulphur 75%
Dry lime sulphur 15%
Arsenate of lead 10%

Dust No. 10

Superfine sulphur 70%
Dehydrated copper sulphate. 5%
Hydrated lime 15%
Arsenate of lead 10%

The standard 90-10 sulphur-arsenate dust was also used in both orchards.

At Raymond City

In the experiments at Raymond City the trees were of the Rome variety, fifteen years old. The equipment consisted of a large power

TABLE 10.—The effectiveness of certain treatments in preventing leaf spot and scab on apple. Leaves collected June 25, 1921.

TREATMENT	BLACK ROT LEAF SPOT						SCAB									
	Distribution of Percentages of Leaves Showing Various Numbers of Spots per Leaf			Average Number of Infected Leaves			Distribution of Percentages of Leaves Showing Various Degrees of Scab			Percentage of Leaves Missing						
	No Spots	1-4 Spots	5-9 Spots	10-24 Spots	25-74 Spots	75 or more Spots	None	Light	Medium	Heavy	Number of Leaves Examined					
Untreated	11.6	14.6	11.7	15.2	16.1	11.9	18.8	78.4	41.1	59.4	14.0	11.3	15.5	40.6	11.1	335
Sulphur Arsenate Dust	71.6	24.6	3.5	0.3				28.4	2.5	79.5	9.4	1.9	20.5	*	371	
Dust No. 10	70.0	25.9	3.3	0.8				30.0	2.5	87.2	8.2	3.6	1.0	12.8	*	390
Dust No. 7	77.3	20.6	2.1	0.0				22.7	2.2	90.7	3.6	4.1	1.6	9.3	*	438

*Less than one percent of leaves gone.

Niagara duster. Late spring frosts destroyed practically all prospect of fruit and it was found impracticable to use a spray outfit. The trees were in blossom unusually early and the first application was made as the petals were falling.

Applications were made as follows:

April 15, All dusts

April 21, All dusts

May 7, All dusts

The trees were thoroughly dusted, from both sides, and received from one to one and one-half pounds per tree, each application.

Table 10 shows that there was very serious injury from leaf spot on unsprayed trees, and many leaves showed more than one hundred spots per leaf. There was not much early infection, and the first three to five leaves on terminal growths (oldest leaves) were comparatively free from leaf spot. Many of the badly infected leaves (11.1%) had already fallen on June 25 when the samples were collected. Most of the scab infection on leaves occurred quite late and the four or five youngest leaves were most injured by it.

All the dust materials were quite effective in controlling leaf infections of both scab and leaf spot.

The fruit data in Table 11 is not very satisfactory because there were very few apples and these were scattered irregularly over the trees. In the case of the check plot seventy-six apples were harvested from seven trees. This included all the apples on the trees and some drops. None of the dusts gave satisfactory control of scab on fruit.

TABLE 11.—The effectiveness of certain treatments in preventing scab and sooty blotch on apple fruit. Fruit harvested September 16 to 18, 1921.

TREATMENT	Distribution of Percentages of Fruits Showing Various Degrees of Scab				Percentage of Scabby Fruit	Percentage of Fruits Affected by Sooty Blotch	Number of Fruits Examined
	None	Light	Medium	Heavy			
Untreated	5.2	18.5	50.0	26.3	94.8	100.0	76
Sulphur-Arsenate Dust	23.7	16.2	42.6	17.5	76.3	100.0	704
Dust No. 10	19.9	33.4	31.1	15.6	80.1	100.0	612
Dust No. 7	23.1	43.5	20.5	12.9	76.9	100.0	225

TABLE 12.—The effectiveness of certain treatments in preventing leaf spot and scab on apple. Leaves collected July 6, 1921.

TREATMENT	BLACK ROT LEAF SPOT						SCAB						Number of Leaves Examined	
	Distribution of Percentages of Leaves Showing Various Numbers of Spots per Leaf			Distribution of Percentages of Leaves Showing Various Degrees of Scab			Percentage of Leaves Missing			Percentage of Leaves				
	No Spots	1-4 Spots	5-9 Spots	10-24 Spots	25-39 Spots	40-59 Spots	None	Light	Medium	Heavy	Severe	Scab Showing		
Untreated	37.0	53.1	9.4	0.5	63.0	2.8	44.2	11.8	18.7	25.2	65.8	4.1	416	
Sulphur-Arsenate Dust	57.0	41.7	1.3	0.0	43.0	1.7	61.0	18.3	14.1	6.6	39.0	13.1	333	
Dust No. 10	59.8	36.8	2.7	0.7	40.2	2.3	68.7	15.1	12.1	4.1	31.3	10.4	438	
Dust No. 7	54.8	41.4	2.9	0.9	45.2	2.4	68.0	12.4	16.0	3.6	32.0	3.9	411	

At Inwood

In the experiments at Inwood the work was conducted in the Silver Hill Orchard. The trees selected were of the Ben Davis variety, and about twenty years old. The equipment consisted of a small Niagara power duster.

The dates of application were:

April 12, All dusts

April 25, All dusts

May 6, All dusts

The average amount of material used per tree for each application was about two and one-half pounds of the sulphur-arsenate dust and Dust No. 7, and about two pounds of Dust No. 10. The trees were dusted from both sides.

Leaf spot infection was most severe on leaves 4 to 7, while the three oldest leaves and the younger ones were relatively free from it. Practically all the leaf scab infection took place even later and was not evident on leaves 5 to 10. It is, therefore, clear that these leaves became diseased after some dust applications had been made. Table 12 shows that both leaf spot and scab infections were reduced somewhat by each of the treatments, but none of the materials gave satisfactory control. At least a portion of the missing leaves could be attributed to frost injury.

The fruit was irregular and scattered on many trees as a result of late spring frost, and this renders the data less satisfactory. It may be seen in Table 13 that the sulphur-arsenate and Dust No. 10 plots showed most scab control, but the results do not speak well for any of the treatments.

TABLE 13.—The effectiveness of certain treatments in preventing scab on apple fruit. Fruit harvested September 21 to 24, 1921.

TREATMENT	Distribution of Percentages of Fruits Showing Various Degrees of Scab				Percentage of Scabby Fruits	Number of Fruits Examined
	None	Light	Medium	Heavy		
Untreated	45.3	45.3	6.4	3.0	54.7	530
Sulphur-Arsenate Dust	71.0	21.9	4.0	3.1	29.0	1720
Dust No. 10	70.0	24.1	4.6	2.3	30.0	1406
Dust No. 7	52.4	34.6	9.6	3.4	47.6	1638

TABLE 14.—The effectiveness of certain treatments in preventing leaf spot and scab on apple. Leaves collected July 2, 1922.

TREATMENT	BLACK ROT LEAF SPOT						SCAB					
	Distribution of Percentages of Leaves Showing Various Numbers of Spots per Leaf			Percentage of Infected Leaves			Percentage of Leaves Showing Various Degrees of Scab			Number of Leaves Examined		
	No Spots	1-4 Spots	5-9 Spots	10-24 Spots	25-49 Spots	50-75 Spots	None	Light	Medium	Heavy	Leaves Showing Scab	Leaves of Leaves
Untreated	28.7	19.2	17.2	23.6	10.2	1.1	71.3	17.5	77.4	16.8	3.4	2.4
Sulphur-Arsenate Dust	76.7	23.3	0.0				23.3	2.1	91.1	7.7	1.2	0.0
Bordeaux Spray	75.0	24.5	0.5				25.0	1.9	93.0	6.7	0.3	0.0
Dry Lime Sulphur Spray	80.3	18.8	0.9				19.7	1.8	92.5	6.2	0.6	0.7
Lime Sulphur Spray	68.3	30.6	1.1				31.7	1.6	92.3	6.4	0.6	0.7
Dust No. 11	83.4	15.8	0.8				16.6	1.7	94.1	4.9	1.0	0.0
Dust No. 12	59.1	33.7	6.3	0.9			40.9	3.1	88.6	7.8	2.1	1.5

EXPERIMENTS IN 1922

The work in the eastern part of the state was transferred from Inwood to Keyser, where a suitable orchard and better equipment were available, while the work in the western part of the state was continued at Raymond City.

Late frosts again interfered with the work by destroying practically all fruit in both experimental orchards. Special dusts used were:

Dust No. 11	Dust No. 12
Superfine sulphur 80%	Dosch copper-lime dust B-8 (con-
Dry lime sulphur 10%	taining 12% monohydrated copper
Arsenate of lead 10%	sulphur and 12.5% lead arsenate)

At Raymond City

The trees in the experimental work at Raymond City were of the Rome variety, sixteen years old. The equipment consisted of a large Niagara power duster and a Bean super giant sprayer. The materials used were 90-10 sulphur arsenate dust, special dust No. 11, special dust No. 12, 3-5-50 Bordeaux spray, 1-40 standard lime-sulphur spray, and the dry lime-sulphur spray. About $\frac{3}{4}$ pound to one pound of dust per tree per application was used in the case of sulphur-arsenate dust and Dust No. 11, while the Dust No. 12 averaged $\frac{1}{2}$ to $\frac{3}{4}$ pound per tree.

Applications were made as follows:

- April 10, All applications (pink spray)
- April 22, All applications (calyx spray)
- May 6, All applications
- May 23, All applications
- June 12, All applications

Scab was not very prevalent and very few leaves showed more than a small area of infection, but leaf spot was quite severe as may be noted in the data in Table 14. There were a few scab spots on leaves 2 to 4, but most of the infection was on leaves 9 to 12, near the tip of terminal growths. Leaves 1 to 3 were quite generally free from leaf spot, while the heaviest infection occurred on leaves 6 to 8. Some of the scab infection took place earlier, but most of it occurred later than the main leaf spot infection.

Each of the treatments was quite effective in reducing the amount of leaf injury from both scab and leaf spot.

At Keyser

In the experiments at Keyser the work was conducted in the Knobley Mountain Orchard upon Rome apple trees about fourteen years old.

TABLE 15.—The effectiveness of certain treatments in preventing leaf spot and scab on apple. Leaves collected July 12, 1923.

TREATMENT	BLACK ROT LEAF SPOT						SCAB								
	Distribution of Percentages of Leaves Showing Various Numbers of Spots per Leaf			Distribution of Percentages of Leaves Showing Various Degrees of Scab			Leaves Showing Scab			Number of Leaves Examined					
	No. Spots	1-4 Spots	5-9 Spots	10-24 Spots	25-49 Spots	50-74 Spots	Percentage Infected Leaves	Average Number of Spots per Leaf	Percentage Infected Leaves	Leaves Showing Scab	Heavy	Medium	Light	None	
Untreated	11.2	21.0	14.7	31.7	19.2	2.2	88.8	15.9	87.6	5.5	4.6	2.3	12.4	652	
Sulphur-Arsenate Dust	74.0	25.6	0.4	0.0	—	—	26.0	1.6	98.7	1.3	—	—	—	1.3	795
Bordeaux Spray	75.8	23.8	1.4	0.0	—	—	24.2	1.9	100.0	0.0	—	—	—	0.0	433
Lime-Sulphur Spray	60.2	35.8	3.3	0.7	—	—	39.8	2.3	100.0	0.0	—	—	—	0.0	575
Dry Lime-Sulphur Spray	54.8	39.4	5.1	0.6	—	—	45.2	2.5	100.0	0.0	—	—	—	0.0	631
Dust No. 12	60.0	28.8	5.3	5.9	—	—	40.0	4.4	100.0	0.0	—	—	—	0.0	372
Dust No. 7	77.6	21.6	0.8	0.0	—	—	22.4	1.7	99.5	0.5	—	—	—	0.5	625

Late frosts destroyed practically all fruit and injured the foliage very seriously, so that the experiment was not carried through to completion, and no data were secured.

EXPERIMENTS IN 1923

The work in the eastern part of the state was again transferred to Inwood, and arrangements were made for securing some data from a large orchard at Rada. The work at Raymond City was continued.

At Raymond City

The trees in the experimental work at Raymond City were of the Rome variety, seventeen years old. The equipment consisted of a large Niagara power duster and a Bean super giant sprayer. The materials used were 90-10 sulphur-arsenate dust, Dosch copper-lime dust B-8 (special dust No. 12), sulphur-lime-sulphur dust (special dust No. 7), 3-5-50 Bordeaux spray, 1-40 lime-sulphur spray, and dry lime-sulphur spray.

Applications were made as follows:

April 20, All materials (pink spray)
May 4, All materials (calyx spray)
May 18, All materials
June 7, All materials
July 12, All materials

About one and one-fourth pounds of material per tree, per application, were used, of sulphur dust and sulphur-lime-sulphur dust, while about three-fourths pound was used in the case of Dust No. 12.

Leaf spot infection was quite general and severe but the scab injury was negligible as shown in Table 15. Leaves 1 and 2 were generally free of leaf spot, while the heaviest infection occurred on leaves 5 to 9 of terminal growths. Scab spots were found almost exclusively on leaves 7 to 10.

Each of the materials was quite effective in reducing leaf spot injury. The Dust No. 7 (sulphur-lime-sulphur) appeared to be best, and the sulphur arsenate dust ranked about equal to the Bordeaux spray. Each treatment was also very satisfactory in controlling leaf scab, although the amount of infection on check trees was slight.

The amount of scab infection on fruit as shown in Table 16 was too slight to be of any significance, but there was one hundred percent sooty blotch infection on unsprayed trees. The sooty blotch was almost completely controlled by Bordeaux and lime-sulphur sprays, while the Dust No. 7 (sulphur-lime-sulphur) and sulphur-arsenate dusts were also very effective in controlling it.

TABLE 16.—The effectiveness of certain treatments in preventing scab and sooty blotch on apple fruit. Fruit harvested September 20 to 22, 1928

TREATMENT	Distribution of Percentages of Fruits Showing Various Degrees of Scab				Percentage of Scabby Fruits	Percentage of Fruits Affected by Sooty Blotch	Number of Fruits Examined
	None	Light	Medium	Heavy			
Untreated	96.0	2.9	0.4	0.7	4.0	100.0	1040
Dust No. 12	88.6	8.2	1.8	1.4	11.4	21.7	1326
Sulphur Dust	93.3	3.9	1.2	1.6	6.7	9.2	1021
Bordeaux Spray	95.2	2.5	0.6	1.7	4.8	3.0	1061
Lime-Sulphur Spray	99.2	0.2	0.2	0.4	0.8	0.8	500
Dry Lime-Sulphur Spray	99.2	0.4	0.2	0.2	0.8	20.0	500
Dust No. 7	96.2	2.7	0.5	0.6	3.8	8.1	1000

At Inwood

In the experiments at Inwood the work was conducted in the Silver Hill Orchard, and the trees were Ben Davis variety, twenty-two years old. The equipment consisted of a large Dosch power dust and a Stewart Supersprayer.

The materials used were 90-10 sulphur-arsenate dust, Dust No. and Dust No. 12.

Applications were made as follows:

- April 26, All materials (pink spray)
- May 7, All materials (calyx spray)
- May 19, All materials
- May 31, All materials

The amounts of dust used per tree per application were approximately three pounds each of sulphur-arsenate and of sulphur-lime-sulphur, and two pounds of the Dosch copper-lime.

There was practically no scab infection on leaves, and it may be seen from Table 17 that the amount of leaf spot was relatively small. Leaf data were not secured from the sprayed plot. None of the treatments was effective in controlling leaf spot.

Table 18 shows that there was a moderate amount of scab infection on the fruit but that it was well controlled by both of the sulphur dusts and the spray.

TABLE 17.—The effectiveness of certain treatments in preventing black rot leaf spot on apple. Leaves collected July 10, 1923.

TREATMENT	Distribution of Percentages of Fruits Showing Various Number of Spots per Leaf				Percentage of Infected Leaves	Average Number of Spots per Infected Leaf	Number of Leaves Examined
	No Spots	1-4 Spots	5-9 Spots	10-24 Spots			
Untreated	63.3	35.3	1.2	0.2	36.7	1.8	470
Sulphur-Arsenate Dust	62.0	37.4	0.6	0.0	38.0	1.6	443
Dust No. 7	56.4	41.8	1.8	0.0	43.6	1.8	540
Dust No. 12	50.5	43.8	4.3	1.4	49.5	2.5	420

TABLE 18.—The effectiveness of certain treatments in preventing scab on apple fruit. Fruit harvested October 14 to 15, 1923.

TREATMENT	Distribution of Percentages of Fruits Showing Various Degrees of Scab				Percentage of Scabby Fruit	Number of Fruits Examined
	None	Light	Medium	Heavy		
Untreated	64.8	25.2	6.8	3.2	35.2	2330
Sulphur Dust	96.8	2.8	0.4	0.0	3.2	2480
Dust No. 12	90.0	6.3	3.0	0.7	10.0	2002
Dust No. 7	98.5	0.0	0.0	1.5	1.5	2740
Lime-Sulphur Spray	98.8	0.9	0.3	0.0	1.2	2330

At Rada

A block of Rome apple trees about twelve years old was selected for the experimental work at Rada. A large Niagara power duster and a power sprayer were used. Bordeaux dust was used except for the application ten days after petal fall. The 90-10 sulphur-arsenate dust was used for the application ten days after petal fall, and Niagara copper-lime dust for apples was used for all others.

Applications were made as follows:

May 1, Lime sulphur spray (pink spray)
May 2, Copper lime dust (pink spray)
May 14, Copper lime dust and lime sulphur spray (calyx spray)
May 24, Lime sulphur spray
May 25, Sulphur lime dust
June 1, Copper lime dust
June 14, Copper lime dust
June 28, Copper lime dust

Six applications were made on the dusted plot. Complete data were not secured, but the owner reported no success whatever in controlling scab with the dust, while spray was very satisfactory. The fruit from the dusted plot was kept separate when it was sent to the packing house and the inspector there reported very heavy scab infection on fruit from dusted plots but practically none on fruit from sprayed plots. Some boxes of typical fruit from the two plots were sent to the laboratory at Morgantown and furnished evidence that the statements of the owner and the inspector were correct.

EXPERIMENTS IN 1924

The work at Raymond City was discontinued in 1924, but the experiments were carried on at Inwood. The copper-lime dusts were discontinued because they had been found to cause considerable injury to fruit and foliage and they were not so effective as the sulphur dusts for the control of the diseases in question. The sulphur-lime-sulphur dust was also omitted as it did not appear to be enough more efficient than sulphur to warrant the extra cost of the material.

The 90-10 sulphur-arsenate was the only material used. Forty-five of the trees were dusted on both sides on the same date; while seventy trees were dusted twice as many times, but using the dust alternately on one side of the trees and then a few days later on the other side. Late frosts destroyed a large portion of the fruit in the section of the orchard where the experiments were under way and the remaining fruit was so badly russeted by frost that no effort was made to secure data from the plots.

DISCUSSION AND SUMMARY

The question, as to the practicability of apple orchard dusting in West Virginia, has seemed to be a matter of great economic importance to everyone interested in orcharding, and every reasonable effort has been made to secure satisfactory control of the prevailing orchard diseases by the use of dust mixtures.

It is entirely possible that the development of new materials or equipment may make dusting a more satisfactory treatment against

our most prevalent and destructive plant diseases. The authors are, however, inclined to the opinion that the problem of disease control in commercial apple orchards of West Virginia is likely to be solved in other ways, so far as the immediate future is concerned.

In our mountain section the varying and almost incessant winds are a serious handicap to the successful application of dust mixtures and it is very difficult for commercial orchardists to find laborers who are willing to be on the job at the hours best suited for making dust applications.

The leaf infection data secured during several seasons gave evidence indicating the approximate time of leaf spot and scab infections, as well as showing the relative amount of disease on foliage. Leaf data from check trees covering four years in the Stewart orchard and three years in other orchards did not show in any case a heavy general infection of the first three (oldest) large leaves on terminal growths. Isolated cases of fairly heavy infections of the first three leaves did occur and the twigs bearing such leaves were doubtless located close beneath some branches heavily infected with the black rot fungus.

Cone shaped areas of infection may frequently be found just beneath a dead twig or branch, and such infections often take place at about the time the trees come into bloom. In the orchards observed here was, however, a later, general infection of foliage by the leaf spot organism. It was this general infection which caused most of the injury. The fact that the first leaves were so often immune at the time of infection indicates that destructive black rot leaf spot infections do not normally occur until after petal fall, under West Virginia conditions.

The successful control of leaf spot was undoubtedly due in part to the fact that the general infection usually occurred soon after the ten day or two-weeks application, and in part of the non-progressive nature of the disease. The leaf spot infection does not normally spread from leaf to leaf, as is the case with scab.

Scab infection was also very light on the first three leaves, although there was rather general but light infection on these leaves in 1919. Heavy scab infection was practically never found until the sixth or seventh leaf was reached and most infection was on leaves eight to ten, well out toward the tip.

This infection data would indicate that under West Virginia conditions, both scab and leaf spot should be readily controlled by thorough applications of fungicides beginning in the cluster bud or pink stage.

CONCLUSION

Experiments extending over a period of eight years, including different locations and orchards, indicated that dust mixtures, at their present stage of development, were not effective or satisfactory, for the control of several outbreaks of apple scab, under West Virginia conditions.

Dust mixtures were more satisfactory for the control of black root leaf spot than for scab, and gave better control of scab on foliage than on fruit.

Upon varieties which are resistant to scab, or during seasons when the amount of scab infection is slight, the use of dust mixture would undoubtedly be satisfactory in West Virginia commercial orchards.



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